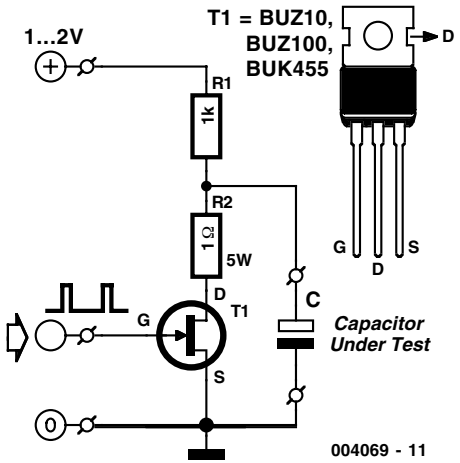
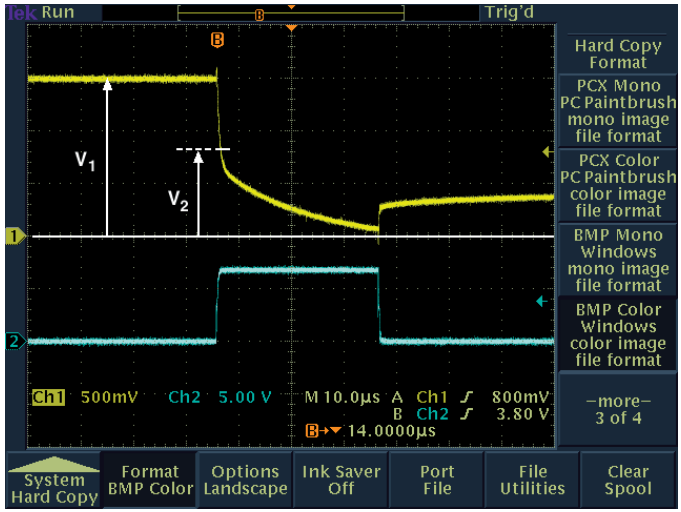
002 ESR Measurements





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In a switch-mode power supply, the quality of the output voltage depends strongly on the quality of the electrolytic capacitors that are used. Here the effective series resistance (ESR), which is the internal 'ohmic' impedance of the capacitor, is one of the most important factors, since large currents are involved. It is rather difficult to *exactly* measure the ESR, but if you only want a quick idea, or you want to compare different families of capacitors, the illustrated simple measurement setup is very suitable.

The capacitor under test is charged via the 1-kΩ resistor (R1) until its voltage is the same as the applied supply voltage. You can then calculate the ESR using the formula (U1/U2) – 1 (see trace 1 of the oscillogram). This formula is very simple, since we have chosen a value of 1 Ω for R2. The values of the supply voltage and R1 are not critical, since the measurement is relative (as shown by the formula). The capacitor is discharged via a 1-Ω resistor and a power FET. You would expect the discharge to occur according to the well-known exponential formula, but as you can see from the oscillogram, the voltage first drops quickly, after which the expected exponential curve appears. This fast initial drop is due to the ESR of the capacitor, which produces a voltage drop equal to the product of the resistance and the discharge current. The greater the voltage drop, the poorer the capacitor.

If the initial voltage drop is approximately equal to half of the charge voltage, as in this case, then we can deduce that the ESR is approximately equal to the discharge resistance of 1 Ω. This is actually a relatively good value for a small, inexpensive 10-µF electrolytic capacitor. As a general rule, you can assume that the ESR decreases proportionally as the capacitance increases, and that it also decreases slightly as the voltage on the capacitor increases.

You can drive the FET directly from a pulse waveform generator, if it can deliver a short positive pulse to the gate with an amplitude of at least 6 V (see trace 2). The repetition interval must be 100 to 1000 times as long as the width of the positive pulse, since the capacitor will otherwise not have enough time

to recharge. In most cases, you will only be able to obtain a stable image on the oscilloscope if it has a storage function. Almost any type of FET can be used, as long as the total discharge resistance (the sum of R2 and R_{ds} of the FET) is as close as possible to 1 Ω.

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